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A Taxonomic Revision of the *Allium virgunculae* Complex (Alliaceae)

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Allium virgunculae F. Maek. & Kitam. was revised and divided into two distinct species, *A. virgunculae* and *A. kiiense* (Murata) Hir. Takah. & M. Hotta (stat. nov.). *Allium virgunculae* was further subdivided into three varieties, var. *virgunculae*, var. *yakushimense* M. Hotta and var. *koshikiense* M. Hotta & Hir. Takah. (var. nov.).

Key words: Alliaceae, *Allium kiiense*, *Allium virgunculae*, *Allium virgunculae* var. *kiiense*, *Allium virgunculae* var. *koshikiense*, *Allium virgunculae* var. *yakushimense*, Liliaceae

Allium virgunculae F. Maek. & Kitam., from Hirado Island, Nagasaki Prefecture, Japan, was described as having such distinct characters as leaves not fistulose, the scape without cauline leaves and arising separately from a tuft of leaves (Kitamura 1952). Later two varieties were recognized within *A. virgunculae*; var. *kiiense* Murata from the southern Kii Peninsula and Aichi, Gifu and Yamaguchi prefectures (Murata 1972), and var. *yakushimense* Hotta from Yakushima Island, Kagoshima Prefecture (Hotta 1998).

Plants of *Allium* in the Koshiki Islands, Kagoshima Prefecture have often been identified with *A. thunbergii* or *A. chinense* (e.g. specimens in KAG), but they are very similar to *A. virgunculae* because the scape lacks cauline leaves and occurs separately from a tuft of thin leaves (see also Hotta 1998). It was uncertain, however, whether the plants from the Koshiki Islands should be assigned to *A. virgunculae* or not. We compared them with *A. virgunculae* and describe them as a new variety, *A. virgunculae* var. *koshikiense* M. Hotta & Hir. Takah. *Allium virgunculae* var. *kiiense* Murata, however, is distinct from the other varieties in some features, especially in floral morphology, and we propose to treat it as an distinct species, *A. kiiense* (Murata) Hir. Takah. & M. Hotta.

Materials and Methods

Localities of the living plants used for this investigation are shown in Table 1. For chromosome observations, the root tips were pretreated in 0.05% colchicine for 3 h, and then fixed in an acetic acid-alcohol mixture (1:3). After washing they were macerated in 1N-HCl at 60°C for 1 min, and squashed in 1% aceto-orcein.

Results and Discussion

Morphological observations

Plants from Koshiki Islands were confirmed to have the same characters as *Allium virgunculae*. The scapes of these plants lack cauline leaves and occur separately from a tuft of thin leaves (see also Hotta 1998). Morphological features of the leaves and the flowers are shown in Table 2. The orientation of the flowers was also distinctly different between *Allium virgunculae* and *A. kiiense*; the flowers open upwards in all varieties of *Allium virgunculae*, but sideways or obliquely downward in *A. kiiense* (Fig. 1). Additionally, there are some distinct features between the two species. The inner tepals are flat in *A. virgunculae*, while boat-shaped in *A. kiiense* as are the outer tepals. The ovaries of *Allium kiiense* are slightly larger than those of *A. virgunculae*. Each of the three carpels composing an ovary protrudes upward. The protrusion is remarkable in

TABLE 1. Localities of living plants examined, with chromosome number (*2n*) and voucher specimen indicated.

A. virgunculae var. *virgunculae*	
Hirado Isl., Nagasaki Pref.	$2n = 16$ (*H. Takahashi 21265* in GIFU*)
A. v. var. *yakushimense*	
Yakushima Isl., Kagoshima Pref.	$2n = 16$ (*H. Takahashi 22406* in GIFU*)
A. v. var. *koshikiense*	
Koshiki Isl., Kagoshima Pref.	$2n = 16$ (*H. Takahashi 22407* in GIFU*)
A. kiiense	
Sakahogi-cho, Mashita-gun, Gifu Pref.	$2n = 16$ (*H. Takahashi 20870* in GIFU*)
Hichisou-cho, Mashita-gun, Gifu Pref.	$2n = 16$ (*H. Takahashi 20865* in GIFU*)
Kiwa-cho, Minamimuro-gun, Mie Pref.	$2n = 16$ (*H. Takahashi 21267* in GIFU*)
Kumano City, Mie Pref.	$2n = 16$ (*H. Takahashi 21266* in GIFU*)

* The Herbarium of Gifu University

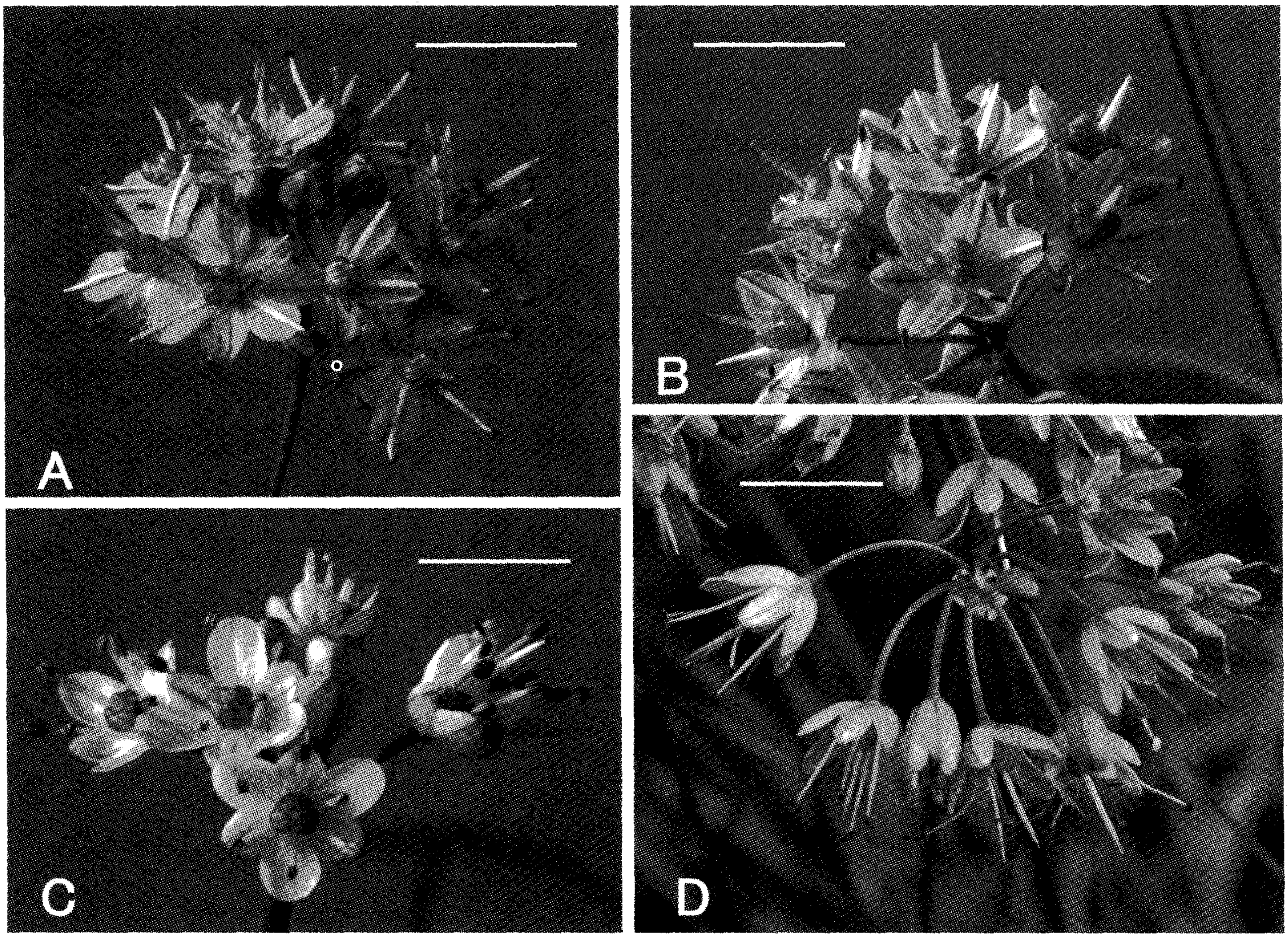

FIG. 1. Flowers of *Allium virgunculae* var. *virgunculae* (A), var. *yakushimense* (B), var. *koshikiense* (C), and A. *kiiense* (D). Bar = 1 cm.

Allium kiiense, especially in the plants from the Kii Peninsula. Those of *A. virgunculae* var. *yakushimense* protrudes upwardly to be separated from the style. The convex cap structure between the carpel protrusions is most conspicuous in plants of *A. kiiense* from Gifu Prefecture, and rather weak in development in the varieties of *A. virgunculae* var. *yakushimense* and var. *koshikiense* (Fig. 2). The style of *Allium kiiense* is fairly long; 4 mm long at staminate stage and 7–10 mm long in the pistillate stage, the style of *A. virgunculae* is 1–1.5 mm long at the staminate stage and 3–5 mm long at the pistillate stage, the filaments of *A. kiiense* are also longer than *A. virgunculae*; 7–10 mm long in the former, and 5–6 mm long in the latter. The leaves are least thick in *Al-*

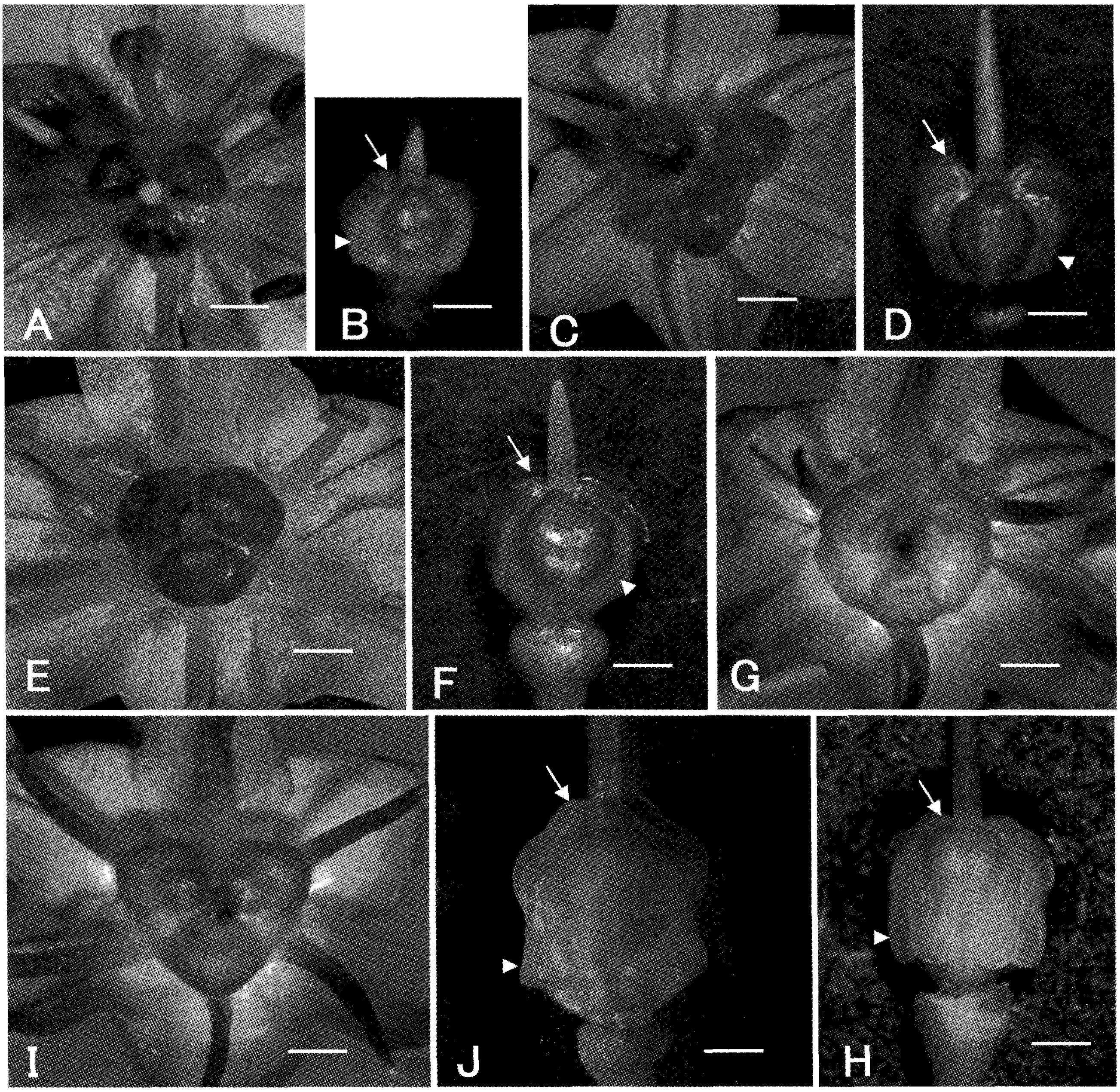

FIG. 2. Ovaries of *Allium virgunculae* var. *virgunculae* (A, B), var. *yakushimense* (C, D), var. *koshikiense* (E, F), and *A. kiiense* (G–J). A, C, E, G & I: over view. B, D, F, H & J: side view. G & H: plant from Sakahogi-cho, Gifu Pref. I & J: plant from Kiwa-cho, Mie Pref. Arrow indicates carpel protrusion; triangle indicates convex cap structure. Bar = 1 mm.

lium virgunculae var. *virgunculae* and become thicker in order from var. *yakushimense*, to var. *koshikiense*, and to *A. kiiense*. The leaves are fistulose in the latter three taxa, but not fistulose in *A. virgunculae* var. *virgunculae* although some of the thiner leaves may not be fistulose in var. *yakushimense* (Hotta 1998). Hollow leaves appear to coincide with increase in diameter, and probably depends on leaf thickness.

Chromosomes

Chromosome numbers for *Allium virgunculae* var. *virgunculae* (Kurita 1953, 1968, Kayano 1992) and var. *yakushimense* (Hotta 1998) were already reported as $2n = 16$. In *A. kiiense* the plants from Kozagawa-cho in Wakayama Prefecture, the type specimen of *A. virgunculae* var. *kiiense*, and from Unuma in Gifu Prefecture had chromosome numbers of $2n = 16$, the plants from Chomonkyo in Yamaguchi Prefecture had a count of $2n = 33$ (Murata 1972). All the plants examined in this investigation showed a chromosome number of $2n = 16$ (Table 1, Fig. 3). Fourteen chromosomes were median or submedian

TABLE 2. Comparison of distinctive characters in *Allium virgunculae* and A. *kiiense*

	A. v. var. *virgunculae*	*A. v.* var. *yakushimense*	*A. v.* var. *koshikiense*	*A. kiiense*
Leaf				
Length	to 25 cm	to 30 cm	to 25 cm	to 40 cm
Width	ca. 1 mm	1.0–1.5 mm	1.5–2.0(–2.2) mm	1.5–2.5 mm
Inside	not fistulose	fistulose (most leaves)	fistulose	fistulose
Receptacle width	ca. 1.3 mm	ca. 1.7 mm	ca. 2.2 mm	1.8–2.0 mm
Floral direction	upward	upward	upward	obliquely downward
Perianth opening	widely spreading	widely spreading	widely spreading	not widely spreading
Perianth color	pale reddish purple (rarely white)	thin purple	pinkish white	reddish purple
Outer tepal				
Shape	boat-shaped	boat-shaped	boat-shaped	boat-shaped
Length	4–6 mm	ca. 5 mm	3.5–4 mm	5–6 mm
Width	2.5–4 mm	ca. 4 mm	3.5 mm	2.5–4mm
Inner tepal				
Shape	flat	flat	flat	boat-shaped
Length	4–6 mm	ca. 6 mm	5–5.5 mm	5–6 mm
Width	2.5–4 mm	ca. 4 mm	ca. 3.5 mm	2.5–4mm
Filament length	5–6 mm	ca. 6 mm	5–6 mm	7–10 mm
Anther length	ca. 1.5 mm	ca. 1.2 mm	ca. 1.0 mm	ca. 1.8 mm
Teeth of outer stamen	yes	yes	yes	yes
Teeth of inner stamen	yes	sometimes yes	no	sometimes yes
Ovary				
Length	2.0–2.8 mm	ca. 3 mm	ca. 3 mm	3.5–4.0 mm
Width	2.2–2.5 mm	3.0–3.2 mm	2.8–3.1 mm	2.8–3.5 mm
Style				
Length at staminate stage	ca. 1.5 mm	ca. 1.0 mm	ca. 1.0 mm	ca. 4 mm
Length at pistillate stage	4–5 mm	ca. 5 mm	ca.3 mm	7–10 mm

types and two chromosomes with satellites were subterminal types in all the plants examined (Fig. 4). The karyotypes were very similar to the karyotype of *Allium virgunculae* var. *virgunculae*, which was reported by Kurita (1968) and Kayano (1992).

Conclusions and Taxonomic Treatments

Allium kiiense, which was described as a variety of *A. virgunculae* by Murata (1972), differs from *A. virgunculae* in many floral characters. One of the most distinct features is floral orientation: the flowers of *A. virgunculae* open upwards and those of *A. kiiense* open sideways or obliquely downward, suggesting that they have different pollination mechanisms. We therefore treat it as a distinct species. The plants with a chromosome number of $2n = 33$ from Yamaguchi Prefecture, live plants of which could not be obtained in this investigation, remain to be examined in detail. The plants of *Allium* from the Koshiki Islands are similar to *A. virgunculae* var. *yakushimense* in having thick, fistulose leaves, but differ in that the flowers are smaller, the floral receptacle is conspicuously larger and the leaves are thicker (Fig. 3). The carpels of the plants from the Koshiki Islands protrude toward the style, while those of var. *yakushimense* protrude upwardly and are separated from the style. We therefore describe the plants from the Koshiki Islands as a new variety of *A. virgunculae*.

Key to *Allium kiiense* and the varieties of *A. virgunculae*

1. Flowers opening sideways or obliquely downward, inner tepals boat-shaped ………… 2. *A. kiiense*
1. Flowers opening upwards; inner tepals flat ………… 1. *A. virgunculae*
  2. All leaves not fistulose; perianth pale reddish purple or white; receptacle 1.3 mm wide ………… 1-1. var. *virgunculae*
    3. Perianth pale reddish purple ………… 1-1-1. f. *virgunculae*
    3. Perianth white ………… 1-1-2. f. *albiflorum*
  2. All or most leaves fistulose excepting some thinnest ones
    4. Most leaves fistulose except thinest ones; perianth light purple; outer tepals widely oblong, ca. 5 mm long, ca. 4 mm wide; inner tepals oblong, ca. 6 mm long, ca. 4 mm wide; receptacle 1.7 mm wide ………… 1-2. var. *yakushimense*
    4. All leaves fistulose; perianth pinkish white; outer tepals broadly ovate, 3.5–4 mm long, ca. 3.5 mm wide, inner tepals broadly ovate, 5–5.5 mm long, 3.5 mm wide; receptacle 2.2 mm wide ………… 1-3. var. *koshikiense*

1. **Allium virgunculae** F. Maek. & Kitam. in Acta Phytotax. Geobot. 14: 148 (1952). —*Type*. Japan, Kyushu, Nagasaki, Hirado Is., Mt. Nyobu 100–200 m alt., 15 Nov. 1950, *S. Kitamura & M. Tamura s.n.* (KYO).

1-1. var. **virgunculae**
1-1-1. f. **virgunculae**

Japanese name. Ito-rakkyou

Distribution. Japan (Nagasaki Pref.) (Fig. 6), endemic.

1-1-2. f. **albiflorum** S. Toyama in J. Jap. Bot. 36: 256 (1961). —*Type*. Japan, Kyushu, Nagasaki, Hirado Is., Mt. Sasidake, 18 Nov. 1960, *S. Hiramatsu s.n.* (Herb. Biol. Inst., Fac. Lib. Arts, Nagasaki Univ.)

Japanese name. Otome-rakkyou

Distribution. Japan (Nagasaki Pref.), endemic.

1-2. var. **yakushimense** M. Hotta in Acta Phytotax. Geobot. 49: 66 (1998). —*Type*. Japan, Kyushu, Kagoshima Pref., Yakushima Is., Mt. Shichigo-dake, 4 Oct. 1996, *F. Iwagawa s.n.* (KAG).

Japanese name. Yakushima-ito-rakkyou

Distribution. Japan (Kagoshima Pref.) (Fig. 6), endemic.

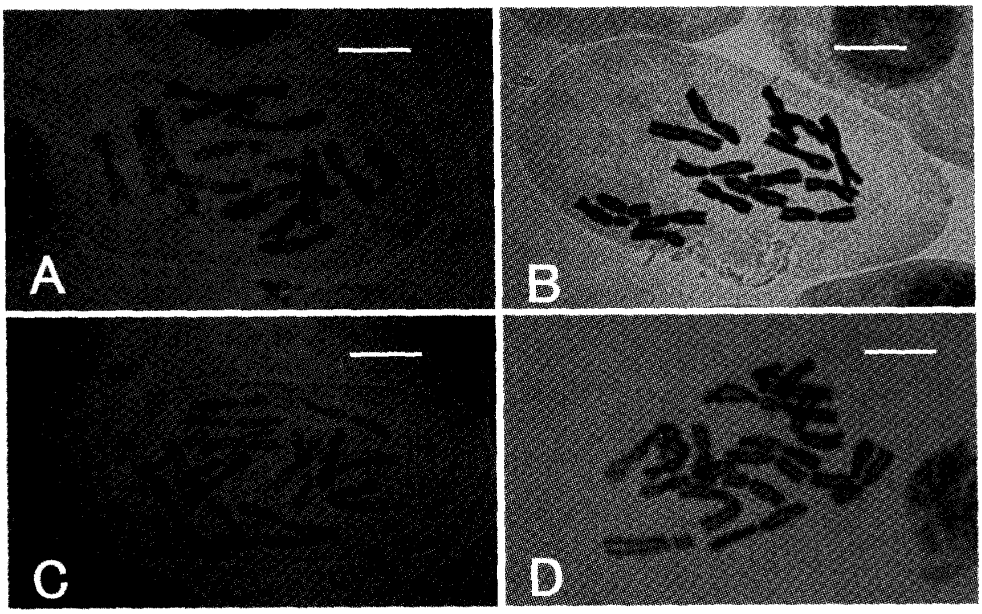

FIG. 3. Photographs of somatic chromosomes at metaphase of *Allium virgunculae* var. *yakushimense* (A), var. *koshikiense* (B), *A. kiiense* from Sakahogi-cho, Gifu Pref. (C) and *A. kiiense* from Kiwa-cho, Mie Pref. (D). Bar = 10 μm.

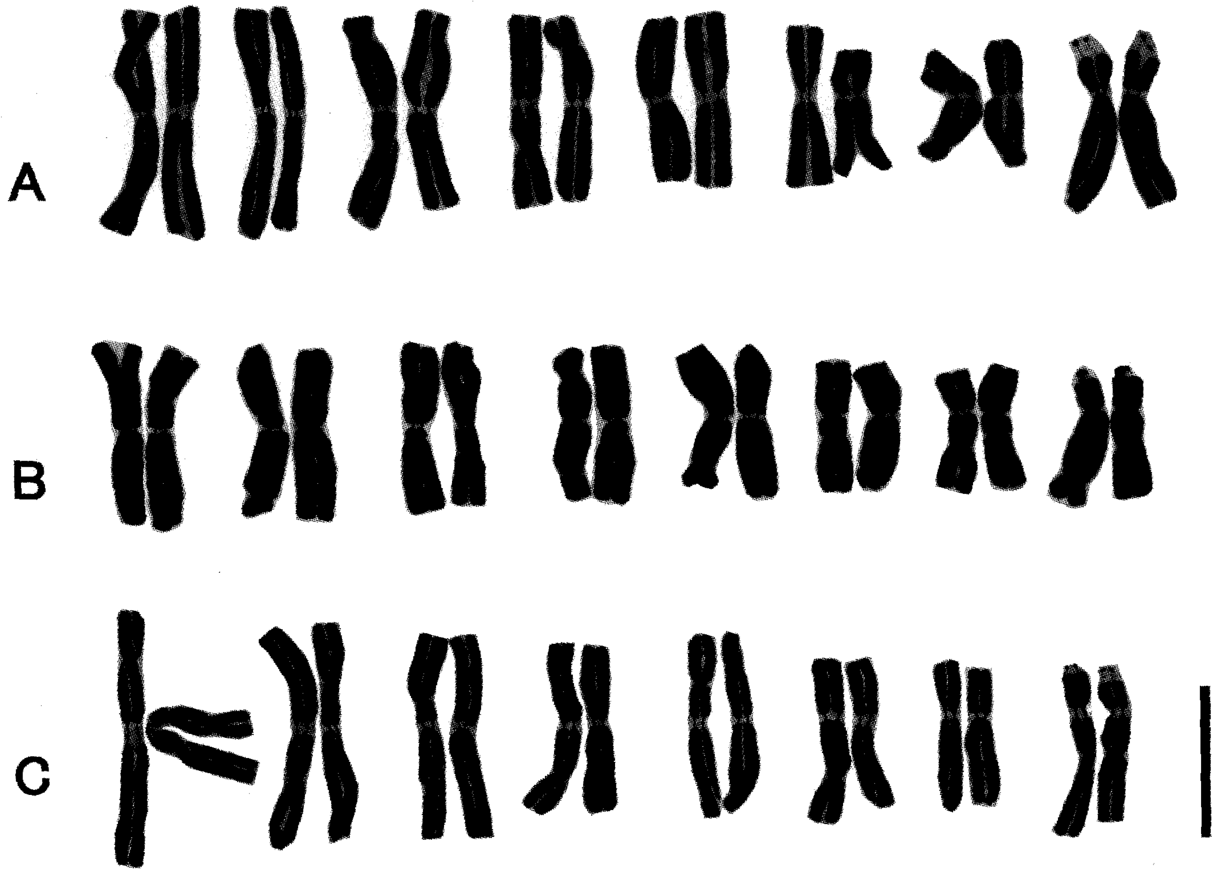

FIG. 4. Karyotypes of somatic chromosomes at metaphase of *Allium virgunculae* var. *yakushimense* (A), var. *koshikiense* (B), and *A. kiiense* from Sakahogi-cho, Gifu Pref. (C). Bar = 10 μm.

1-3. var. **koshikiense** M. Hotta & Hir. Takah., **var. nov.**

Allium virgunculae var. *koshikiense* M. Hotta, Red Data Plants of Kagoshima: 431, fig. 187 (2003), nom. nud.

A var. *virgunculae* foliis fistulosis et a var. *yakushimensi* receptaculo majore differt.

Typus. JAPAN, Kami-koshikijima, Satsuma Prov. (Kagoshima Pref.), 15 Dec. 1957, *S. Sako 1628* (KAG).

Herbs, perennial, evergreen. *Bulbs* lanceolate, ca. 2 cm long, ca. 7 mm wide. *Scapes* 10–20(–30) cm tall. *Leaves* linear, circular in cross section, fistulose, 15–25 cm long, 1.5–2(–2.2) mm wide. *Flowers* late October to November, 10–15 per umbel, erect. *Spathe* ovate, cirrose, whitish, membranous, 6–7 mm long. *Pedicels* slender, 10–15 mm long. *Perianth* nearly horizontally spreading, pinkish; tepals broadly ovate, apex obtuse; outer tepals dorsally concave, 3.5–4 mm long, ca. 3.5 mm wide, inner tepals 5–5.5 mm long, 3.5 mm wide. *Stamens* spreading; filaments narrowly lanceolate, basally flat, 5–6 mm long; base fused

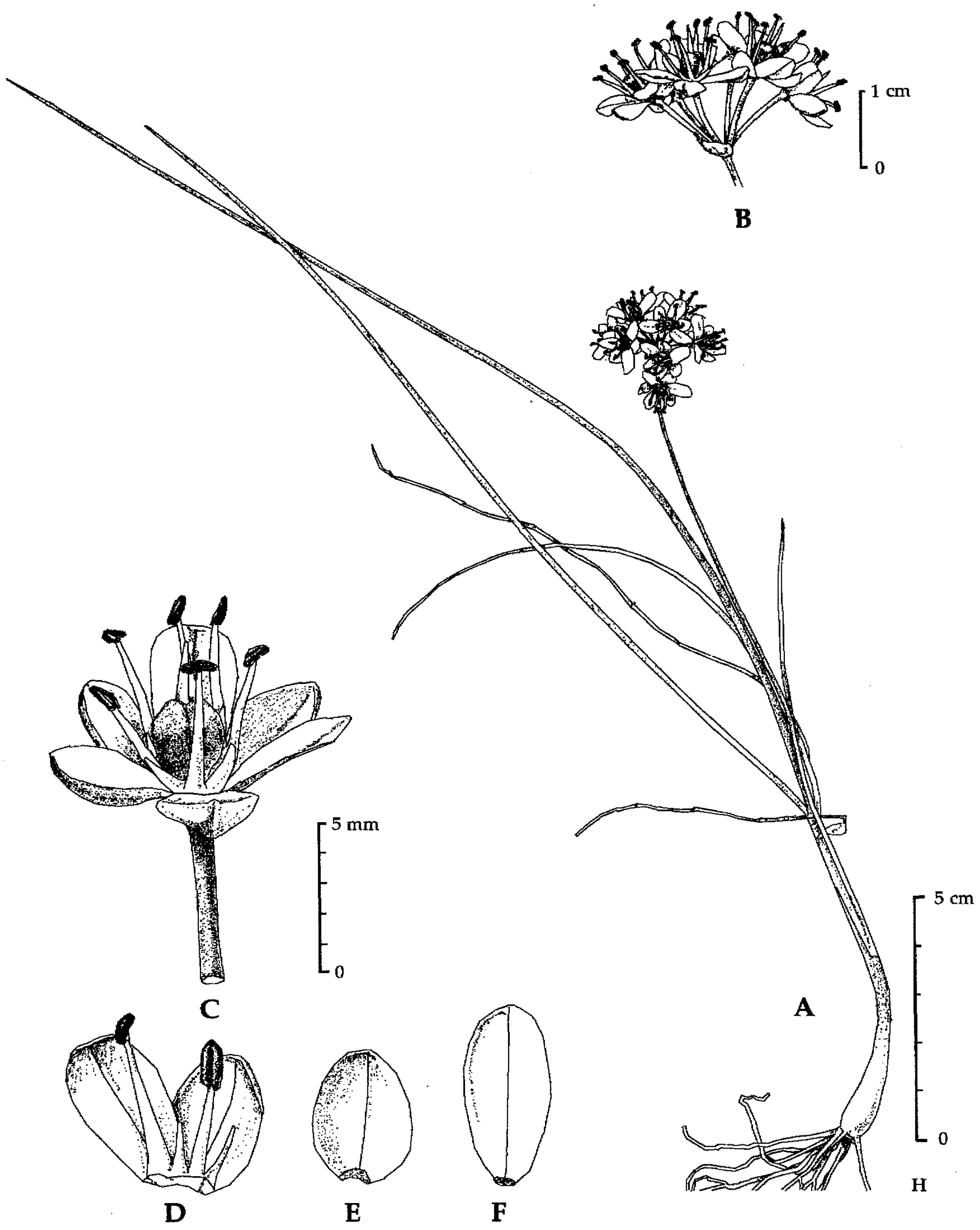

FIG. 5. *Allium virgunculae* F. Maek. & Kitam. var. *koshikiense* M. Hotta & Hir. Takah. A: entire plant. B: inflorescence. C: flower. D: tepals with stamens. E: outer tepal. F: inner tepal.

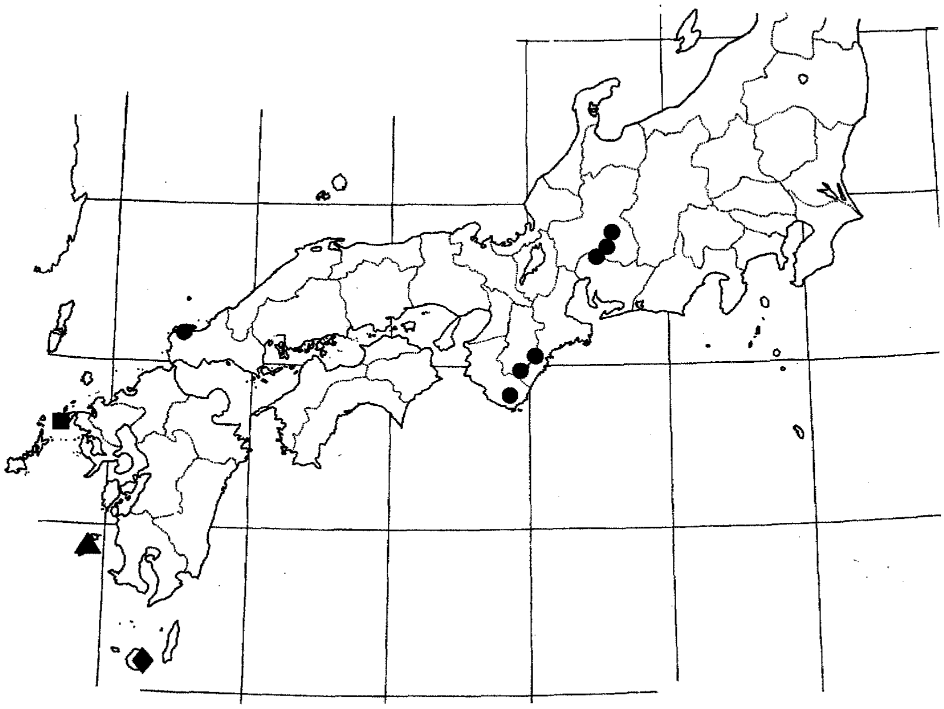

FIG. 6. Distribution of *Allium virgunculae* var. *virgunculae* (■), *A. virgunculae* var. *yakushimense* (◆), *A. virgunculae* var. *koshikiense*(▲), and *A. kiiense* (●).

to form a ring, adnate to tepals; ring with teeth between filaments ca. 2 mm long; anthers purple, ca. 1 mm long; pollen pale dark blue. *Ovaries* globose, ca. 3 mm long, 3-locular; nectaries 3 in middle of ovary, with inconspicuous convex cap structure; style ca. 1 mm long in staminate stage, ca. 3 mm long in pistillate stage. Chromosome number $2n = 16$.

Japanese name. Koshiki-ito-rakkyou

Distribution. Japan (the Koshiki Islands) (Fig. 6). On rocks in warm temperate zone.

Other specimens examined. Shimokoshiki, 31 Oct. 1968, *M. Furuse s.n.* (KAG); Shimokoshiki, *K. Kawanabe* 4536 (KAG).

2. **Allium kiiense** (Murata) Hir. Takah. & M. Hotta, **stat. nov.**

Allium virgunculae F. Maek. & Kitam. var. *kiiense* Murata in Acta Phytotax. Geobot. 25: 46 (1972). —*Type.* Japan, Honshu, Wakayama; collected at Kozagawa-cho, Higashimuro-gun, and cult. in Tanabe, 5 Dec. 1970, *Y. Sasano s.n.* (KYO).

Japanese name. Kii-ito-rakkyou

Distribution. Japan (Honshu: Gifu, Aichi, Mie, Wakayama and Yamaguchi prefs.) (Fig. 6), endemic.

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